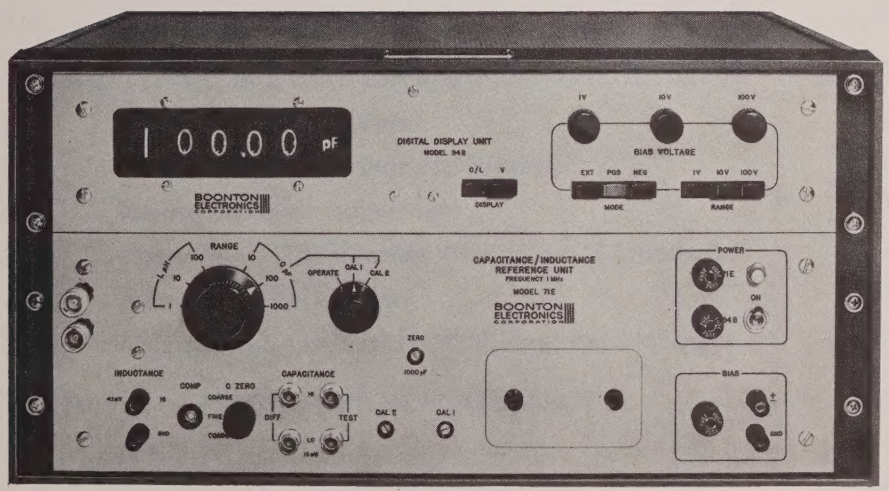
OPERATOR'S MANUAL

for

DIGITAL C/L METER MODEL 700C



700C
a-470

BOONTON ELECTRONICS CORPORATION

TEL: 201-887-5110
TWX: 710-986-8241
ROUTE 287 AT SMITH ROAD
PARSIPPANY, N. J.— 07054

Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_05332

TABLE OF CONTENTS

CHAPTER			PAGE
I	DESCRIPTION AND DATA		
	1.1	Purpose and Description	1
	1.2	Model 700C Configuration	1
	1.3	Measurement Considerations	1
	1.4	Technical Characteristics	2
II	INSTALLATION		
	2.1	Unpacking and Inspection	4
	2.2	Packaging for Reshipment	4
	2.3	Power Connections	4
III	OPERATION		
	3.1	General	6
	PART 1. PRELIMINARY OPERATING INSTRUCTIONS		6
	3.2	Controls and Indicators	6
	3.3	Initial Control Settings and Warmup	11
	3.4	Pre-operational Adjustment	11
	3.5	Capacitance Calibration With Internal Standard	12
	3.6	Inductance Calibration	13
	3.7	Capacitance Calibration With External Standards	13
	PART 2. CAPACITANCE MEASUREMENTS		15
	3.8	General	15
	3.9	Remote Measurement Considerations	15
	3.10	Measuring Capacitance Specimens	15
	3.11	Correcting for Cable Inductance	17
	3.12	Extending the C ZERO Range	17
	3.13	Differential Measurements	17
	3.14	Applying DC Bias	18

TABLE OF CONTENTS (CONT'D)

CHAPTER		PAGE
	PART 3. INDUCTANCE MEASUREMENTS	21
3.15	Measurements	21
3.16	Remote Measurement Considerations	21
	PART 4. SYSTEM APPLICATIONS	23
3.17	General	23
IV	THEORY OF OPERATION	
4.1	Digital Display Unit	25
4.2	C/L Reference Unit	27
APPLICATION NOTES		Following Page 28

LIST OF ILLUSTRATIONS

FIGURE		PAGE
1	Model 700C	A
2	Controls and Indicators	5
3	Correction for Cable Inductance in Capacitance Measurement	16
4	Connections For External Bias	20
5	Connection Error, Lead Inductance in Inductance Measurement	22
6	External Connections	23
7	Block Diagram, 700C	28

TABLES

TABLE		PAGE
1	Technical Characteristics	2
2	Controls and Indicators	6
3	Initial Control Settings	11
4	External Connections	24

LISTS OF REPLACEABLE PARTS — Following APPLICATION NOTES

Logic Circuit Timing Diagrams — Endfold

Schematics — Endfold

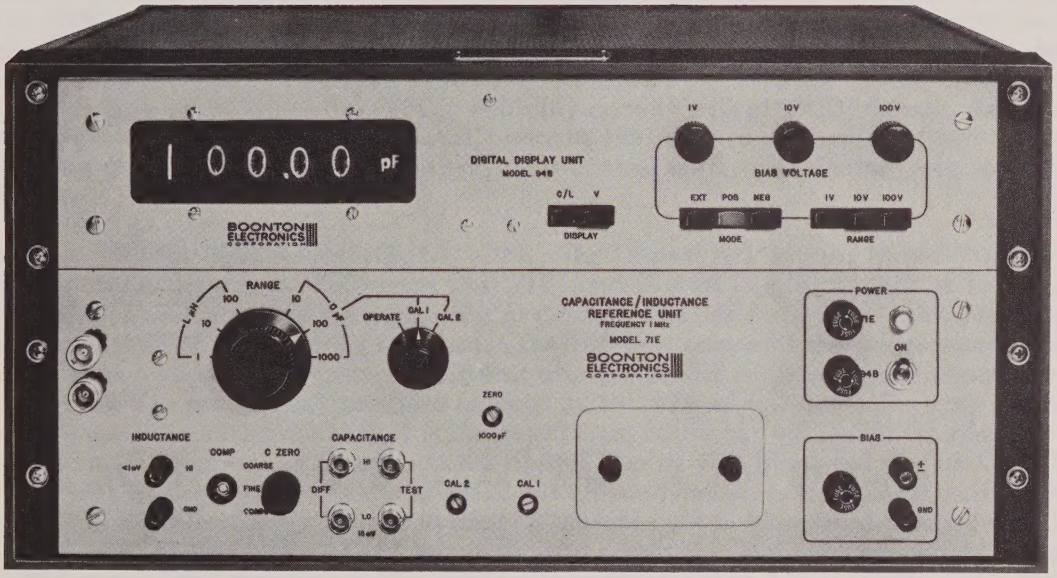


Figure 1. Digital C/L Meter Model 700C

CHAPTER I

DESCRIPTION AND DATA

1.1 PURPOSE AND DESCRIPTION. The Digital C/L Meter, Model 700C, Figure 1, is a self-contained, digital type test equipment used to perform precise measurements of three-terminal capacitance specimens and two-terminal inductance specimens at 1 MHz. The 700C also provides and measures a dc bias voltage that is variable in three separate ranges: 0 to ± 1.3999 V, 0 to ± 13.999 V, 0 to ± 139.99 V. All measured values are illuminated and displayed on a digital type indicator. Test specimens may be connected to the 700C by means of coaxial cables and a test jig, or they may be connected directly to the front panel terminals. A pair of BNC-to-binding-post adapters are stored on the front panel to facilitate direct connections to the 700C. An internal 100 pF capacitance standard is used to calibrate the 700C. A binary coded decimal (BCD) output, available at a rear panel printed circuit connector, permits the 700C to be used in system applications for driving printers, tape or card punches, data control units, and similar interfacing data equipment.

1.2 MODEL 700C CONFIGURATION. The Digital C/L Meter, Model 700C, consists of Capacitance/Inductance Reference Unit 71E, and Digital Display Unit/Bias Supply Model 94B. The 71E unit provides the measuring functions, supplies the 1 MHz test signal, and contains the 100 pF capacitance standard. The 94B unit computes the measurement and displays it as a plus or minus numeric readout along with the applicable measurement mode symbol. The 94B provides an accurate readout up to 140% of full-scale for each measurement range. However, a fifth digit is displayed from 100% to 140% of full-scale. If the 40% overrange tolerance is exceeded, the digital display will blank out and an OVERRANGE warning will be displayed until the RANGE switch is advanced to a higher measurement range. The 94B Bias Supply is used to apply a variable ± 140 V internal bias voltage between the 71E CAPACITANCE HI and LO terminals (and across any specimen connected either to the TEST or the DIFF terminals). If a bias voltage greater than 140 V is required, the internal supply can be bypassed and an external dc source, up to ± 200 volts, may be connected to the 71E BIAS terminals. The 700C measures and indicates only up to ± 140 V dc, and neither the internal nor external bias appears across the INDUCTANCE terminals.

1.3 MEASUREMENT CONSIDERATIONS. The 700C ignores stray capacitance from the LO post to ground and measures the capacitance value of the test specimen only. The stray capacitance from the HI post to ground has no significant influence above 10 pF, and the effects of stray capacitance below 7 pF can be negated by the 71E COMP adj control. The COMP adj control also is used to negate the capacitance introduced by coaxial cables during remote measurement, and the direct capacitance introduced by a test jig can be balanced out by the 71E C ZERO control. Thus, specimens can be connected either locally or remotely to the 700C without incurring errors caused by capacitance from either side of the test to ground. However, when coaxial cables are used to connect specimens to the 700C, the effects of series inductance introduced by the cables must be taken into consideration because erroneous readings can result. The correction for series inductance errors is a simple procedure and is discussed in paragraphs 3.9 and 3.11.

1.4 TECHNICAL CHARACTERISTICS. The characteristics of the Digital C/L Meter, Model 700C, are shown in the following table.

Table 1. Technical Characteristics

MEASUREMENT AND OTHER CHARACTERISTICS

Capacitance Measurements (3-terminal):

Range ..... 0 to 1000 pF

Accuracy ..... 0.25% of reading + (0.1% + $\frac{3}{Q}$ %)fs + 0.002 pF

Where: Q = Q of test specimen

Resolution ..... 4 digits

Inductance Measurements (2-terminal):

Range ..... 0 to 100 μH

Accuracy ..... 0.5% of reading + (0.5% + $\frac{6}{Q}$ % + $\frac{L\mu H}{500}$ %)fs +0.0005 μH

Where: $L_{\mu H}$ = test specimen inductance
Q = Q of test specimen

Resolution ..... 4 digits

Test Signal:

Frequency ..... 1 MHz, crystal controlled, ± 0.02%

Level:

Capacitance measurements....15 mV, rms, ± 1 mV

Inductance..... < 1 mV, rms

Bias Supply:

Internal bias..... 0 to ± 139.99 V, continuously variable, in three ranges: 0 to 1.3999, 0 to 13.999, 0 to 139.99, fused, & digitally monitored

External bias ..... Up to ± 200 V at 250 mA may be applied at fused BIAS terminals; 0 to ± 139.99 V digitally monitored.

Table 1. Technical Characteristics (Cont'd)

Voltage monitory accuracy	± 0.5% fs (± 2 digits)
Regulation	Limits at approximately 10 mA on any of the three ranges.

Digital Display Unit:

BCD Output	4-line (8,4,2,1), where logic 1 $\geq$ 4 V and logic 0 $\leq$ 0.4 V
Power Requirements	117 V or 234 V, ± 10%; 50 to 60 Hz
Power Consumption	42 watts
Dimensions	19-1/2" wide, 9-7/8" high, 17-7/8" deep
Weight	41 lbs.

CHAPTER II
INSTALLATION

2.1 UNPACKING AND INSPECTION. Remove the packing material from the shipping carton and carefully remove the 700C. If feasible, the carton and packing material may be stored for possible future reshipment. Carefully inspect the 700C for any damage that may have occurred during shipment. If there is any damage or defect, notify either your local Sales Engineering Representative or the Boonton Electronics Corporation.

2.2 PACKING FOR RESHIPMENT. If required, pack the 700C for reshipment to the manufacturer in accordance with the following shipping instructions:

a. If possible, use the original shipping carton and packing material.

b. Coil the power cable inside the rear panel compartment.

c. Tie a tag or envelope to the BIAS binding post and include the following information:

(1) Name and address of purchaser.

(2) Model number and serial number of equipment.

(3) Full description of damage or defect.

2.3 POWER CONNECTIONS. Check to see that the ac power source is the same as that specified on the equipment nameplate, and connect the power cable plug to a power receptacle.

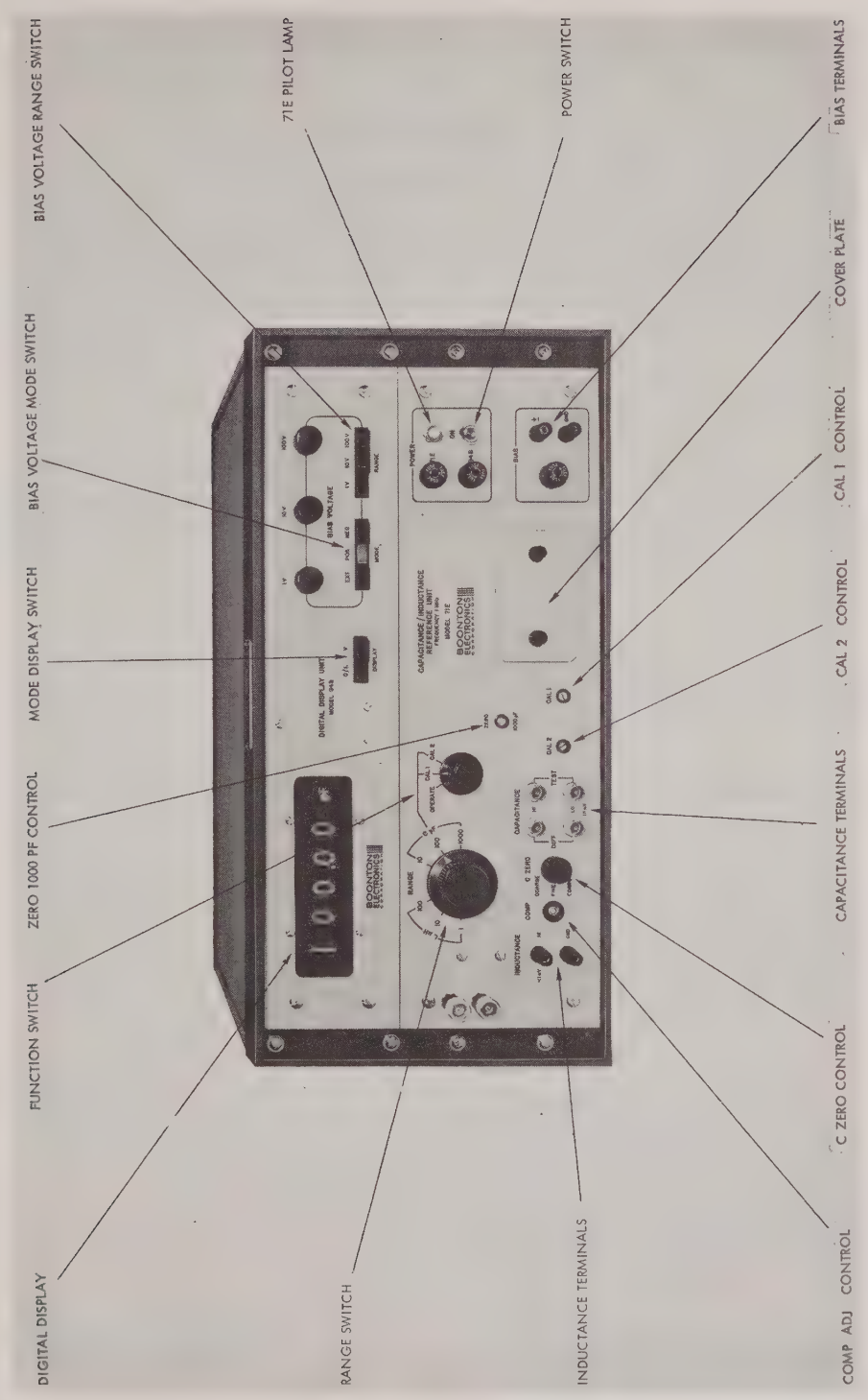


Figure 2. Model 700C Controls and Indicators

CHAPTER III

OPERATION

3.1 GENERAL. This chapter contains operating instructions for the 700C and includes procedures for capacitance (C) and inductance (L) measurements, bias application, C differential measurements, correcting for external cable inductance, and calibrating the 700C. Before attempting any measurements, observe the preliminary operating instructions in Part I, below.

PART I. PRELIMINARY OPERATING INSTRUCTIONS

3.2 CONTROLS AND INDICATORS. The controls and indicators of the 700C are illustrated in Figure 2 and are functionally described in Table 2. Thoroughly review the function of each item in the table before performing any adjustments or measurements on the 700C.

Table 2. Controls and Indicators

COMPONENT	DESCRIPTION - FUNCTION
71E Unit:	
INDUCTANCE HI and GND terminals	Binding posts used to connect inductors to the 700C.
RANGE switch	7-position rotary switch used to select measurement mode and range. LμH 1, 10, and 100 positions used for inductance measurements, and CpF 10,100, and 1000 positions used for capacitance measurements. Top-center position can be used to check DVM zero.
Function switch	3-position rotary switch designated as OPERATE, CAL 1, and CAL 2. The OPERATE position is used when measuring capacitance or inductance. The CAL 1 and CAL 2 positions respectively provide a high-Q and low-Q internal 100 pF capacitance standard for calibration.
CAPACITANCE TEST HI and LO terminals	BNC connectors used to connect capacitance specimens to the 700C. Specimens may be connected directly (using BNC-to-binding-post adapters discussed below) or remotely by means of coaxial cables and a test jig.

Tabel 2. Controls and Indicators (Cont'd)

COMPONENT	DESCRIPTION-FUNCTION
CAPACITANCE DIFF HI and LO terminals	BNC connectors used to connect capacitance specimens to the 700C, as discussed above. A capacitance connected to the CAPACITANCE TEST terminals produces a positive reading, while the same capacitance connected to the CAPACITANCE DIFF terminals causes a comparative negative reading. The CAPACITANCE DIFF terminals are used to make differential capacitance measurements, and to extend the range of the C ZERO control.
BNC-to-binding-post adapters	Adapters are stored on the 71E front panel to be used to connect test specimens directly to the CAPACITANCE TEST or DIFF terminals.
C ZERO control	Continuously variable control used to balance out capacitance introduced across the CAPACITANCE terminals by connecting leads or a test jig. The C ZERO control can neutralize up to approximately 7 pF of cable or jig capacitance, but its range may be increased by connecting an external capacitance to the CAPACITANCE DIFF terminals (par. 3.12). For about 270 degrees of rotation, the C ZERO control turns easily, and then the torque requirement increases sharply as the control shifts from a 36:1 FINE ratio to a 6:1 COARSE ratio.
ZERO 1000 pF control	Screwdriver-adjust control used to zero the 1000 pF position of the RANGE switch. Proper alignment of the 1000 pF RANGE switch circuit is essential for accurate measurements of both capacitance and inductance. The 1000 pF position on the RANGE switch should be checked periodically. The ZERO 1000 pF control has the same vernier drive described for the C ZERO control, above.
COMP adj control	Screwdriver-adjust control used to negate stray capacitance between the inner conductors of the CAPACITANCE TEST

Table 2. Controls and Indicators (Cont'd)

COMPONENT	DESCRIPTION - FUNCTION
	and DIFF HI BNC connectors and the outer conductors. The COMP adj control can tune out approximately 100 pF. Normally, stray capacitance is balanced out on the 10 pF range only, because the amount of stray capacitance required to cause a 1% error is more than two times the full-scale of the range used. When measuring on the 10 pF range, adjust the COMP adj control under the following circumstances: a. When the 700C is first operated. b. When the specimen connection system is changed (e.g., from cables or test jig to direct connection). c. When measuring a capacitance standard. d. When a specimen has a markedly different HI-post-to-ground capacitance (caused by different internal construction, encasing, or terminations) than specimens measured previously.
BIAS terminals	Binding posts used to connect external bias voltages, up to ± 200 volts at 250 mA, to the 700C. The applied bias voltage appears across the CAPACITANCE TEST and DIFF terminals but not across the INDUCTANCE terminals. The digital display will readout external bias up to 140 V(100 V+ 40% overrange) if mode switch is at EXT, DISPLAY switch is at V (voltage), and RANGE switch at appropriate voltage.
BIAS fuse	250 mA fuse in the external-bias input circuit.
CAL 1 control	Screwdriver-adjust control (10 turn) used in conjunction with the function switch CAL 1 position to calibrate the 700C at 100 pF for high Q (>10) measurements.
CAL 2 control	Screwdriver-adjust control (multi-turn) used in conjunction with the function

Table 2. Controls and Indicators (Cont'd)

COMPONENT	DESCRIPTION - FUNCTION
	switch CAL 2 position to calibrate the 700C at 100 pF for low Q (Q=3) measurements.
Power switch	Toggle switch used to control ac power for the 700C.
Pilot Lamp	Glows when the 700C is energized.
71E FUSE	Protects 71E
94B FUSE	Protects 94B
C10, C100, C1000, L1, L10, L100 controls	Screwdriver-adjust controls accessible when front panel cover plate is removed. Each control is labeled to correspond with a RANGE switch position, and the control is used to calibrate the designated switch position. These controls are preset at the factory and should not require adjustment.
71E Rear Panel:	
COARSE CAL 2 control	Screwdriver-adjust control, functions as a coarse adjustment for front panel CAL 2 control.
R415 control	Screwdriver-adjust control used to adjust operating point of internal circuits. This control is preset at the factory and should not be touched.
94B Unit:	
Digital display	Nixie-tube indicators provide + or - numerical readout with the appropriate measurement mode symbol. Four digits are displayed from .0000 to 99.99% of full scale for each RANGE switch setting, and a fifth digit is displayed above 99.99% of full scale. An OVERRANGE warning is activated when the readout reaches 40% above full scale. If the 40% tolerance is exceeded, the readout will blank out.
94B Front Panel:	
Display Switch	Selects either C/L voltage from 71E or bias voltage from internal or external supply.

Table 2. Controls and Indicators (Cont'd)

COMPONENT	DESCRIPTION - FUNCTION
Mode switch	Selects + or - internal bias or external bias.
Voltage range switch	Three-range switch used to establish maximum output of bias voltage level at either 1 V, 10 V, or 100 V. Also sets the range for the digital display when measuring external bias.
1 V, 10 V and 100 V level controls	Used to vary the level of the bias supply output within the limit established by the voltage range switch position. Fully clockwise position produces maximum bias level.

3.3 INITIAL CONTROL SETTINGS AND WARM-UP. Set the 700C controls (Figure 2) in accordance with Table 3, below, and allow at least two hours for warm-up from normal room temperature before proceeding to the pre-operational adjustments in paragraph 3.4.

Table 3. Initial Control Settings

COMPONENT	SETTING OR CONDITION
71E Front Panel:	
RANGE switch	10 pF
Function switch	OPERATE
Power switch	ON (71E pilot lamp glows) (digital display unit indicates).
INDUCTANCE, CAPACITANCE, and BIAS terminals	Free of any specimen or connection
94B Front Panel:	
Display switch	C/L

3.4 PRE-OPERATIONAL ADJUSTMENT. Before making the following adjustments, check that the 700C has warmed up for at least one hour and that the settings and conditions of Table 3 have been observed.

a. Set RANGE switch to vertical position between LμH and 0 pF and check digital display unit zero indication. (If necessary, use zero controls on rear of 94B)

b. Return RANGE switch to 10 pF position.

c. If the BNC-to-binding-post adapters and/or a test jig will be used to connect capacitance specimens (par. 3.8) connect the adapters, jig, or connecting cables as required to the CAPACITANCE TEST HI and LO terminals on the 71E.

d. Adjust the C ZERO control on the 71E until the digital display reads approximately 7.500 pF.

e. Peak the COMP adj control for a maximum reading on the digital display. If the digital display should indicate OVERRANGE, readjust the C ZERO control until the display is on range, and repeak the COMP adj control.

f. Adjust the C ZERO control for a readout of as close to zero as possible. If the BNC-to-binding-post adapters are installed on the CAPACITANCE TEST terminals, minimize operator proximity to the adapters. Hand- or body-capacitance effects may cause variations in readings during the C ZERO adjustment.

g. Set the RANGE switch to 1000 pF and adjust the ZERO 1000 pF control for a readout of zero.

h. Set the RANGE switch to 10 pF and check that the digital readout is as close to zero as possible. If the readout is not near zero, repeat steps d through h.

NOTE:

The proper adjustment of the ZERO 1000 pF control is essential for accurate C and L measurements. During operation, check the 1000 pF Range position occasionally for a readout of zero. If the readout is not at or near zero, perform steps d through h, above.

i. Perform the calibration procedures in paragraphs 3.5 and 3.6, below.

3.5 CAPACITANCE CALIBRATION WITH INTERNAL STANDARD. A 100 pF internal capacitance standard is provided for calibrating the capacitance-measuring circuits in the 700C. This is a three-terminal, 1 MHz standard, and provides calibration options for both high-Q (Q>10) and low-Q (Q=3) measurements.

a. Set the 71E RANGE switch to 100 pF.

b. Set the function switch to CAL 1 (high Q).

c. The digital readout should be 100.00, ± 0.03, pF. If the readout is not within tolerance, adjust the CAL 1 control.

d. Set the function switch to CAL 2 (low Q).

e. The digital readout should be 100.00, ± 0.03, pF. If the readout is not within tolerance, adjust the CAL 2 control. If the CAL 2 control is out of range, set it at middle range and adjust the COARSE CAL 2 control on the rear panel of the 71E until proper ranging is restored.

f. Turn the function switch back to CAL 1 and check that the readout still is 100.00, ± 0.03 pF. If the readout is not within tolerance repeat steps c through f.

g. If the CAL 1 or CAL 2 control was adjusted in steps c or e, above, repeat step f in paragraph 3.4, through step h; and then repeat steps a through f, above, until all readings are within tolerance.

3.6 INDUCTANCE CALIBRATION.

a. Connect a short length of No. 22 AWG copper wire between the INDUCTANCE HI and GND terminals on the 71E. The wire should be taut between the two terminals.

b. Set the RANGE switch to 1μH and check for a readout of .0090, ± 0.0003, μH. If the readout is not within tolerance, adjust L101.

c. Remove the wire from the INDUCTANCE terminals and set the RANGE switch to 10 pF.

d. Set the function switch to OPERATE.

3.7 CAPACITANCE CALIBRATION WITH EXTERNAL STANDARDS. If required, the capacitance-measuring circuits in the 700C may be calibrated at check points other than 100 pF by using high-Q, 1 MHz, three-terminal capacitance standards, such as the Boonton Electronics Model CS-series. The use of low-Q capacitance standards is not recommended; the procedure in paragraph 3.5 provides adequate calibration for low-Q measurements.

a. Connect the high-Q, 1 MHz capacitance standard to the 71E CAPACITANCE TEST HI and LO terminals. The connecting cables should be as short as possible (not more than 3 to 4 inches) for capacitance values >100 pF.

b. Set the RANGE switch to a C_{pF} position consistent with the value of the capacitance standard.

c. Peak the COMP adj control for a maximum readout on the digital display.

d. Disconnect the CAPACITANCE TEST LO cable from the capacitance standard.

e. Adjust the C ZERO control until the digital display reads 0.000, ± 3 on the last digit.

f. Connect the CAPACITANCE TEST LO cable to the capacitance standard and read the value on the digital display.

g. The readout should agree with the value and tolerance of the capacitance standard.

h. If necessary, adjust the CAL 1 control until the readout and the capacitance standard values are in agreement. However, if the CAL 1 control is adjusted, repeat steps f through h in paragraph 3.4, and steps a through g, above, until all readings are within tolerance.

i. Remove the external capacitance standard.

PART 2. CAPACITANCE MEASUREMENTS

3.8 GENERAL. Be sure that the pre-operational adjustments are completed before attempting any measurements described in this section. Capacitance specimens can be measured either locally or remotely. The measurement is local when the specimen is connected directly at the CAPACITANCE TEST HI and LO terminals with the BNC-to-binding-post adapters or a test jig connected directly to the adapters. Perform local measurements in accordance with the procedure in paragraph 3.10. The measurement is remote when the test jig is cable-connected to the 700C. For remote measurements, observe the instructions in paragraph 3.9 before performing measurements (par. 3.10), and correct for cable inductance in accordance with paragraph 3.11. Observe the applicable instructions in paragraph 3.12 through 3.14.

3.9 REMOTE MEASUREMENT CONSIDERATIONS. Use RG-62/U or similar low-capacitance coaxial cables to connect the remote test jig to the 700C. The length of the cable pair should not exceed five feet for measurements on the 10 pF range, and shorter lengths should be used on the higher capacitance ranges. Refer to Figure 3 for cable inductance correction information that may be used as a guide in selecting practical cable lengths. If capacitance specimens are to be measured on the 10 pF range, follow the procedure below before making any measurements.

a. Check that the test jig is connected to the CAPACITANCE TEST HI and LO terminals and the RANGE switch is at 10 pF.

b. Connect a typical test specimen to the test jig terminals.

c. Peak the COMP adj control for a maximum readout on the digital display.

d. Remove the test specimen from the test jig.

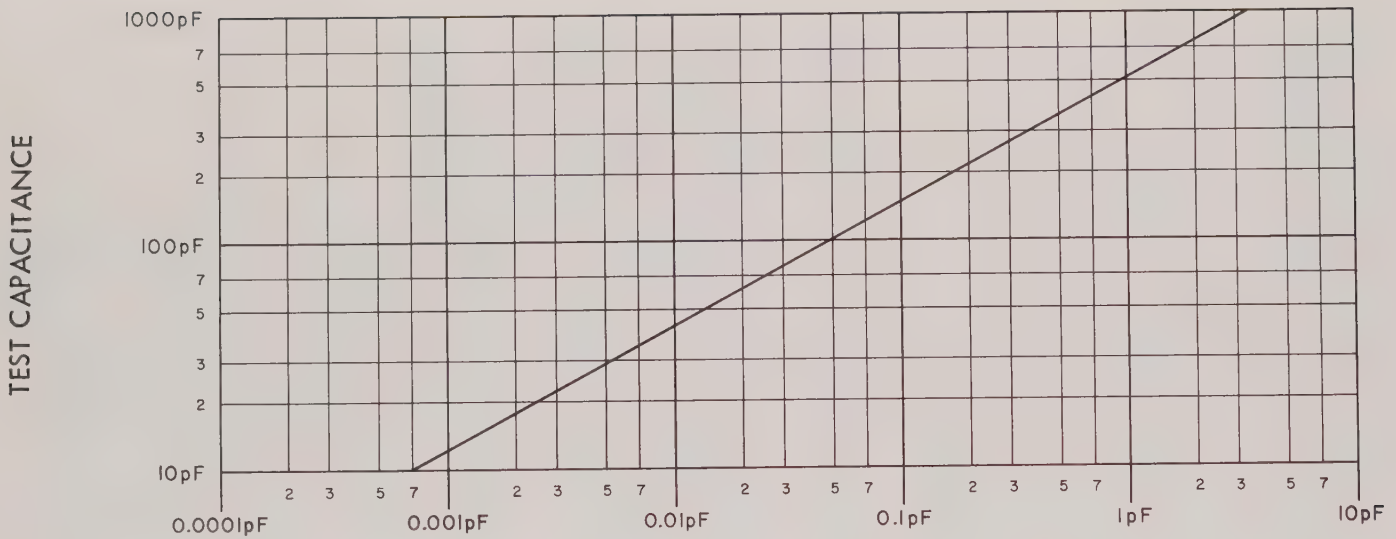
e. If necessary, adjust the C ZERO control for a readout of 0.000, ± 0.003, pF.

3.10 MEASURING CAPACITANCE SPECIMENS.

a. Set the 71E RANGE switch to a C pF position consistent with the test specimen value.

b. Connect the test specimen to the CAPACITANCE TEST HI and LO terminals or to the terminals of any connecting adapters or test jig.

c. Read the value of the test specimen on the digital display.



SUBTRACT pF FROM CAPACITANCE READING FOR EACH
FOOT OF RG-62/U CONNECTING CABLE

NOTES

1. The two cables need not be of the same length. RG-58/U may also be used.
2. Correction for cables of other lengths may be computed as a simple ratio to one foot.
3. Both ends of the cable shields should be well grounded.

(When frequent remote measurements must be made, the Model 71-6B Capacitance Test Terminal Extender eliminates the necessity of making the above corrections).

Figure 3. Correction for Error in Capacitance Measurement Owing to Series Inductance Of RG-62/U Connecting Cables Having Combined Length of 1 Foot.

3.11 CORRECTING FOR CABLE INDUCTANCE. When a test specimen is remotely connected to the 700C, the series inductance of the connecting cables and the inductance of the specimen can cause measurement error. The measured value (C_m) of the test specimen will read higher than the true capacitance (C_t) in accordance with the following expression:

$$C_m = \frac{C_t}{1-\omega^2 LC_t} = \frac{C_t}{1-(X_L/X_{C_t})} \quad \text{or} \quad C_t = \frac{C_m}{1+(X_L/X_{C_t})}$$

Where,

L = the combined series inductance in μH of both lengths of connecting cables and the inductance of the test specimen (generally small compared to cable inductance).

Figure 3 indicates the correction to be made per foot of an RG-62/U pair for measured values ranging from 10 pF to 1000 pF.

3.12 EXTENDING THE C ZERO RANGE. The C ZERO control can balance-out up to 7 pF between either the CAPACITANCE TEST HI and LO terminals or the CAPACITANCE DIFF HI and LO terminals. Occasionally, an external jig assembly may contribute more than 7 pF capacitance and render the C ZERO control ineffective. When required, the range of the C ZERO control can be extended to approximately 30 pF by connecting a high-quality mica capacitor to the CAPACITANCE DIFF HI and LO terminals. Ideally, the value of the mica capacitor should approximate the estimated capacitance contributed by the external fixture.

3.13 DIFFERENTIAL MEASUREMENTS. Use the following procedure to determine the capacitance differential between two specimens. The specimens may be biased (paragraph 3.14) or unbiased, and they can be connected either locally or remotely.

a. Connect the larger value specimen (if known) to the CAPACITANCE TEST HI and LO terminals.

b. Connect the other specimen to the CAPACITANCE DIFF HI and LO terminals.

c. Set the RANGE switch to a position consistent with the value of one of the specimens. If increased resolution is desired, set the RANGE switch to the next lower position, provided the overrange tolerance is not exceeded.

d. Read the capacitance differential directly on the digital display. If a negative readout results, the larger capacitance value is at the CAPACITANCE DIFF terminals, and the two specimens should be interchanged.

3.14 APPLYING DC BIAS. Follow the applicable procedure, below, to bias capacitance specimens that are to be measured on the 700C. In paragraph a, specimens are biased up to ± 140 volts by the internal bias supply. Use the procedure in paragraph b to apply bias from an external source up to ± 200 volts at 250 mA. Paragraph c contains instructions for applying external bias in excess of ± 200 volts. In all cases the bias voltage appears across both the CAPACITANCE TEST and DIFF terminals, and the BIAS fuse protects internal circuits for both internal and external bias applications.

a. Applying up to ± 140 volts.

(1) Set the polarity switch on the 94B to the required polarity. The polarity selected is applied to the CAPACITANCE TEST and DIFF HI terminals.

(2) Set the Display switch to V.

(3) Set the voltage range switch to the applicable position.

(4) Adjust the appropriate level control until the digital display indicates the required voltage level.

(5) Connect test specimens to the CAPACITANCE TEST or DIFF terminals, as required.

b. Applying Bias up to ± 200 volts.

(1) Set the Mode switch to EXT and perform steps a (2) and (3), above.

(2) Connect the output leads of the bias source to the 71E BIAS binding posts, observing the polarity and ground assignments.

(3) Adjust the external bias source to the required voltage level. Do not apply more than 200 volts at 250 mA or the BIAS FUSE may open. The digital display will readout bias up to 140 V (100 V+ 40% overrange).

(4) Connect test specimens to the CAPACITANCE TEST or DIFF terminals, as required.

c. Applying More Than +200 Volts Bias. When biasing requirements exceed ±200 volts, use the circuit in Figure 4 to connect the external bias source to the 700C. Notice that a shorting strap is connected across the 71E BIAS binding posts.

(1) Set the polarity switch to OFF (EXT BIAS).

(2) Adjust the external bias source to the required voltage level.

(3) Connect the biasing circuit (Figure 4) to the HI and LO terminals at either CAPACITANCE TEST or CAPACITANCE DIFF, as convenient.

(4) Connect test specimens in accordance with Figure 4.

Figure 4. Connections For External Bias (Over 200 Volts)

PART 3. INDUCTANCE MEASUREMENTS

3.15 MEASUREMENTS. After the pre-operational adjustments (paragraph 3.4) are completed, inductance measurements may be made in accordance with the procedure given below. When no specimen is connected to the 700C and the RANGE switch is set to a $L_{\mu H}$ position, a digital display blank-out and an OVERRANGE indication will result. However, the digital display will give a normal readout when an inductance specimen is connected to the 700C.

a. Connect a two-terminal inductance specimen directly to the 71E INDUCTANCE HI and GND terminals.

b. Set the RANGE switch to a $L_{\mu H}$ position consistent with the value of the test specimen.

c. Read the value of the test specimen on the digital display.

3.16 REMOTE MEASUREMENT CONSIDERATIONS. The 700C will accurately measure inductance values if test specimens are connected directly to the 71E INDUCTANCE HI and GND terminals. However, when a specimen is connected remotely, the connecting leads introduce inductance and capacitance to the measurement; under these conditions, there will be a small error in the result. A typical example of the error percentage found in remote measurement is shown in Figure 5.

NOTE: The error in remote inductance measurement can be eliminated to a large extent by using the Model 71-7A Inductance Test Terminal Extender.

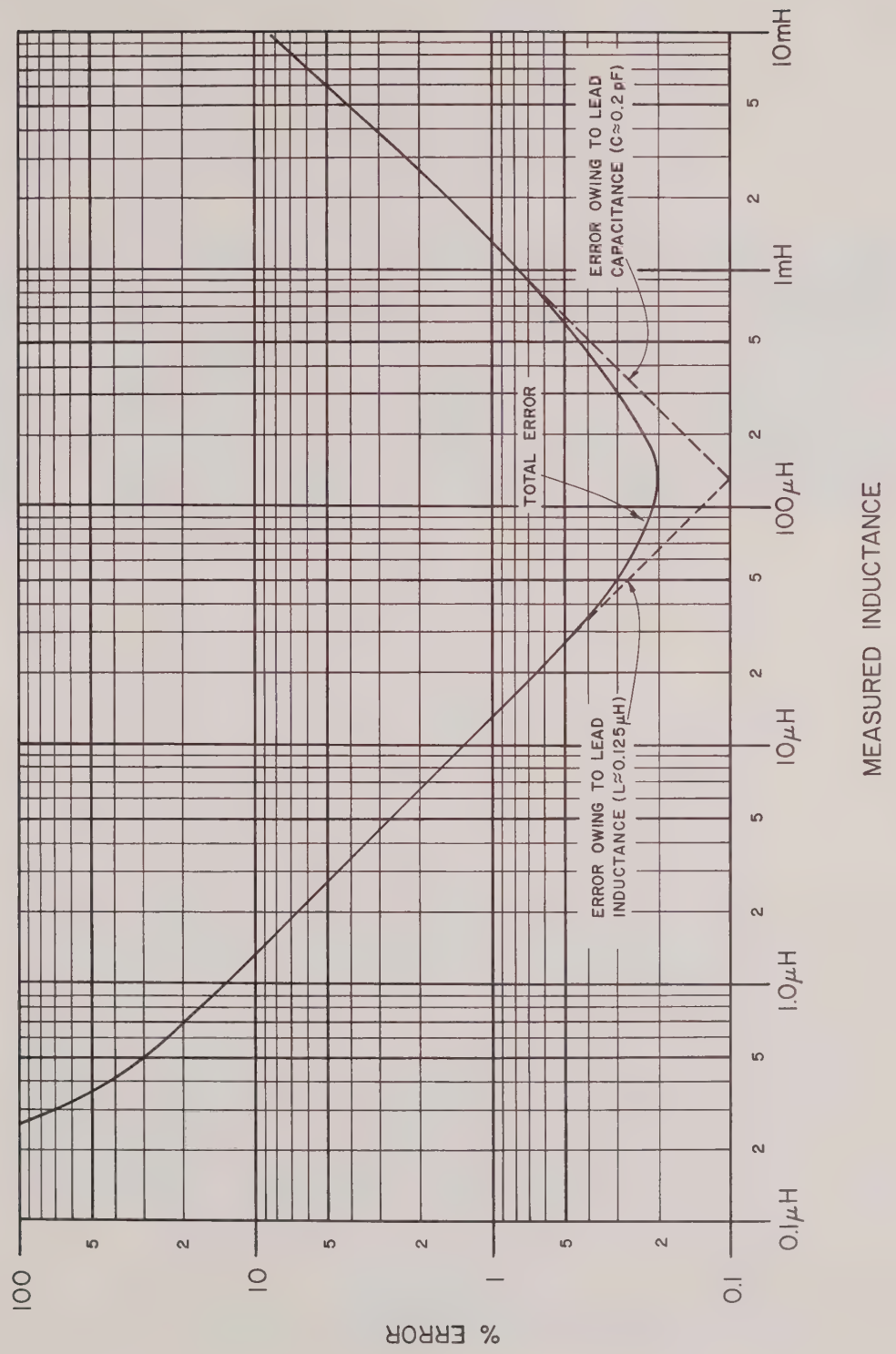


Figure 5. Connection Error Resulting From 3 inch Leads of No. 20 Wire Spaced 3/4 inches Apart.

PART IV. SYSTEM APPLICATIONS

3.17 GENERAL. A BCD output permits the 700C to be used in system applications, as described in paragraph 1.1. When the 700C is an integral part of a system configuration, it may be remotely controlled and triggered manually, or it can be triggered automatically in synchronism with some system event. Provision also is made to apply a code-inhibit input signal to the 700C, if required. This signal can be used to inhibit a conversion process and can eliminate the need for buffer storage. In a typical application, the code-inhibit input signal can be used to momentarily stop the 700C readout until a slower unit, such as a printer or card punch, records data. For system or external requirements, all input and output connections on the 700C are made at the receptacle located on the rear panel of the 94B unit. See Figure 6, below, for receptacle connections. See Table 4 for full identification of the terminals.

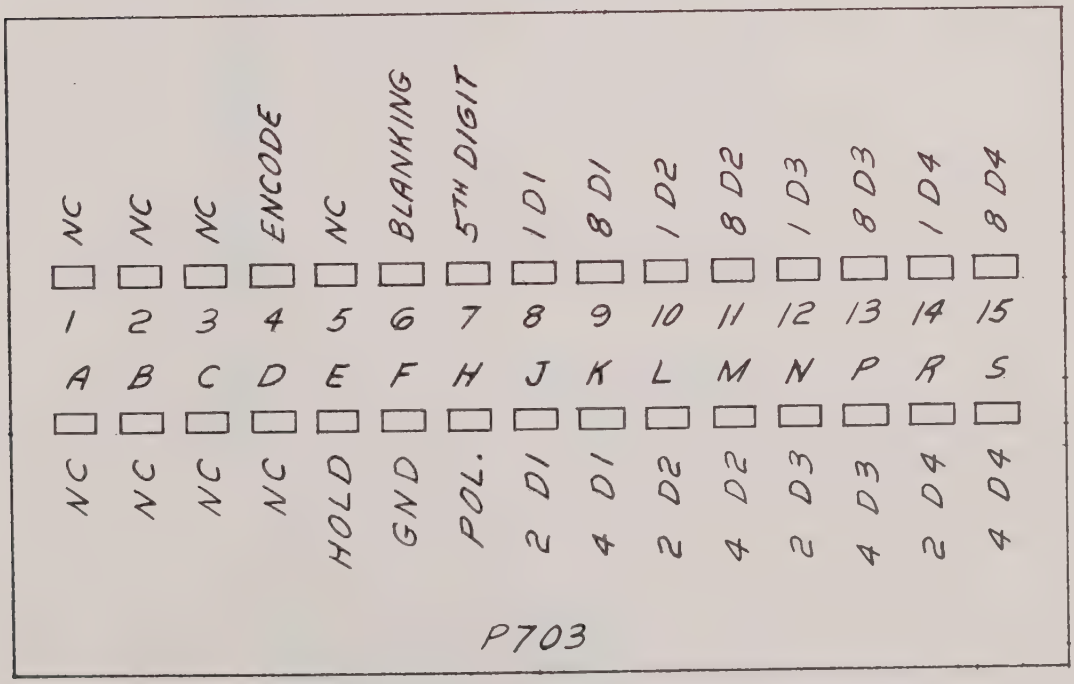


Figure 6. External Connections

TABLE 4

TERMINAL		REMARKS
4	ENCODE output:	Logic 1 = Encode in progress Logic 0 = End of encode
E	HOLD input:	Logic 0 inhibits encode Logic 1 or open circuit enables encode
F	GROUND	
6	BLANKING output:	Logic 0 = Display blanked Logic 1 = Display on
H	POLARITY output:	Logic 1 = + Logic 0 = -
7	5TH DIGIT output:	Logic 0 = 5th digit on Logic 1 = 5th digit off
8	Bit 1	BCD outputs for digit 1 (least significant digit)
J	Bit 2	Logic 1 = Bit on
K	Bit 4	Logic 0 = Bit off
9	Bit 8	
10	Bit 1	
L	Bit 2	Digit 2 BCD outputs
M	Bit 4	
11	Bit 8	
12	Bit 1	
N	Bit 2	Digit 3 BCD outputs
P	Bit 4	
13	Bit 8	
14	Bit 1	
R	Bit 2	Digit 4 BCD outputs
S	Bit 4	(most significant digit)
15	Bit 8	

Logic 1: $V_o \geq +3.4$ volts

$Z_o \cong 150$ ohms

Logic 0: $V_o \leq +0.5$ volts

$Z_o \cong 75$ ohms

Maximum sink current at Logic 0 = 1.6 mA.
(1 std. TTL load)

CHAPTER IV

THEORY OF OPERATION

4.1 DIGITAL DISPLAY UNIT. Basically, the 94B Digital Display Unit converts the dc analog output of the 71E Capacitance/Inductance Reference Unit to digital form. These digital signals are then used to trigger the cathodes of the appropriate Nixie display tubes.

The major circuit blocks of the 94B are the start generator, the operational amplifier circuits, the analog switch circuits, the reference voltage circuits, the polarity and shutdown logic circuits, and the storage and display circuits. In the discussion that follows, reference is made to circuit symbols appearing in the Schematic drawings found at the back of this book.

4.1.1 Start Generator Circuit. Q18 switches at 60 Hz because of the alternating current flowing through R9. The negative-going edge of this square wave is coupled to B2 of Q19. The trigger voltage of Q19 is therefore lowered every 1/60 second for a short time. C30 charges through R76 until the lower trigger voltage points is reached; a short positive pulse then appears of R79 and IC18-2. As long as IC18-1 is open, IC18-3 goes to ground. This is inverted in IC18-4 to IC18-6, and appears as a positive-going pulse on the base of Q20. Q20 saturates for approximately 2 microseconds. This provides the reset and start pulses. C30 recharges and the cycle repeats about every 200 milliseconds.

4.1.2 Operational Amplifier Circuit. The operational amplifier A1 is an amplifier with a closed loop gain of 5, with low drift characteristics. C12 and C15 determine the step response of the operational omplifier. CR11 and CR12 protect the amplifier from high voltage inputs.

4.1.3 Analog Switches. There are four analog switch circuits which use N channel depletion type FET's with low resistance. Q21, R81, R82, and R83 comprise a level shifter. A positive voltage of the input of R81 turns off Q21 and the associated FET. A ground on the input allows R82 to bias Q21 on, turning the FET into its on state.

4.1.4 Reference Voltages. The temperature-compensated voltage across CR15 is divided by R64, R68 and R70. R68 adjusts the voltage applied to R69 and provides a positive reference current. R65, R66 and IC21 comprise a voltage inverter to provide the negative reference voltage. R68 and R72 are adjustable potentiometers used for full scale calibration.

4.1.5 Polarity and Shutdown Logic. R54 and CR16 provide level shifting between the ±15 volt output of IC14 and the 0 to +5 volt input of the gates. IC19-1 and IC19-2 inhibit shutdown during the first 10,000 counts. IC19-3 and IC19-4 inhibit the switches after shutdown. Operation for a positive input is as follows: IC17-2 and IC19-13 are at logic 0, and IC19-12 is at logic 1. IC17-13 and IC17-4, together with IC18-9 go to a logic 1 after 10,000 counts (when IC19-1 goes to 0). IC18-8 goes to logic 0, setting the polarity flip-flop (IC15-6, IC15-9, IC15-8, IC15-5). IC17-1 goes to logic 0, keeping IC17-12 at logic 1. Q19 turns on due to the logic 0 on IC18-8. As the integrator passes through zero, IC17-2 and IC18-13 go to a logic 1. IC19-12 goes to a logic 0, IC18-8 goes to a logic 1. IC17-6 now goes to a logic 0 and sets the flip-flop consisting of IC15-1, IC15-11, IC15-3 and IC15-12. This shuts down the oscillator and drives IC18-11 to zero, transferring the counter outputs into the storage register. IC19-4 drives IC17-4, IC17=13 and IC18-9 to zero, turning off Q23 and Q16.

Operation for a negative input is as follows: IC17-2 and IC19-13 are at logic 1. IC17-4, IC17-13 and IC18-9 go to a logic 1 at 10,000 counts. IC17-12 goes to 0, turning on Q17. IC18-8 remains at a 1 due to the zero on pin 10. As the ramp passes through zero, IC17-2 and IC19-13 go to a logic 0. IC17-12 goes to a 1 before C25 can charge. IC17-6 goes to a 0 and sets the shutdown flip-flop. From this point on, operation is the same as in the positive input case.

4.1.6 Storage and Display Circuits. IC1, IC2, IC3 and IC4 are decade counters used to provide 1 - 2 - 4 - 8 BCD outputs. Each counter is reset by a logic 1, and a reset width of at least 1 microsecond is required to insure that all four counters are reset.

IC5 is a quad latch. When pin 4 and pin 13 are at logic 1, the information present

on the input pins is transferred into storage; it remains in storage as long as pins 4 and 13 are at logic 0.

When the output pins of IC9 go low, the BCD-to-decimal driver lights the associated Nixie cathode.

The storage transfer line is normally low during operation. The counters are reset and then count. When the encode has been completed the line labelled "XFER IN" goes low and the XFER line is driven high for about 3 microseconds. Counter outputs are transferred to the storage flip-flops in IC5 and to the decoder-Nixie driver inputs. When the XFER line goes low again, IC5 is used to store the BCD information until the next pulse.

4.2 C/L REFERENCE UNIT. The capacitance measuring network of the 71E unit is basically a series circuit in which the current is sensibly proportional to the susceptance of the capacitor being tested. This is achieved by using a low-impedance test voltage generator whose level is tightly controlled at a level of approximately 15 millivolts, and a calibrated detector whose input conductance is large relative to the susceptance of the test capacitor.

The quadrature relationship of the test capacitor and the detector is helpful in providing an output indication that is a linear function of capacitance. To improve the linearity further, and to suppress the influence of the test capacitor's loss, the detector is phase-sensitive to the susceptance of the test specimen only. The linearity achieved is better than 0.1% of the value. Range switching is done by changing the input conductance of the detector.

The instrument measures the direct capacitance or the three-terminal capacitance of specimens. Stray capacitance to ground appearing across the generator does not affect the reading, owing to the negligible impedance of the generator. Capacitance across the detector input has little effect on the measurement except for the three lowest ranges. On these ranges, however, a parallel-resonant circuit can be adjusted to absorb the shunt capacitance to ground across the detector.

The inductance measuring network of the 71E is the dual of the capacitance network; a constant current is passed through the test specimen and the detector senses the resultant voltage across the specimen.

The block diagram below (Figure 7) shows the basic configuration of the 700C in simplified form.

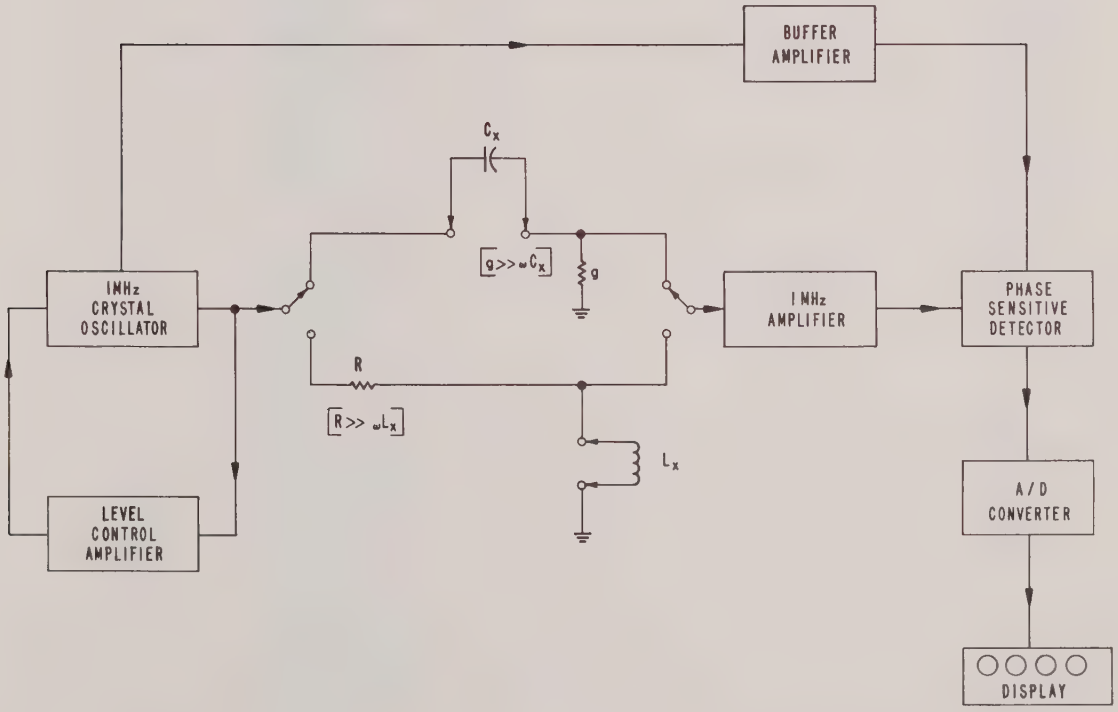


Figure 7. Block Diagram, 700C

TABLE OF REPLACEABLE PARTS
DIGITAL VOLTMETER

NOTE: The Digital Voltmeter is a purchased assembly. In the Table below, BEC Part Numbers have not yet been assigned to the individual components listed. In the event that a component requires replacement, please call Boonton Electronics.

Reference		Description	Part Number
R1	Resistor	1.5K 1/4 W	RC07
R2	"	1.0K 1/4 W	"
R3	"	2.7K 1/4 W	"
R4	"	4.99K 1%	RN60D
R5	"	3.48K 1%	RN60D
R6	"	3.3K 1/4 W	RC07
R7	"	7.15K 1%	RN60D
R8	"	7.5K 1%	RN60D
R9	"	10K 1/4 W	RC07
R10	"	470Ω 1/4 W	"
R11	"	3.9K 1/4 W	"
R12	"	33K 1/4 W	"
R13	"	68K 2 W	2W
R14	"	47K 1/4 W	RC07
R15	"	3.3K 1/4 W	"
R16	"	1K 1/4 W	"
R17	"	4.7K 1/4 W	"
R18	"	33K 1/4 W	"
R19	"	100K 1/4 W	"
R20	"	1K 1/4 W	"
R21	"	4.7K 1/4 W	"
R22	"	33K 1/4 W	"
R23	"	68K 1/2 W	RC20
R24	"	1K 1/4 W	RC07
R25	"	4.7K 1/4 W	"
R26	"	1K 1/4 W	"
R27	"	4.7K 1/4 W	"

700C
a-470

Reference		Description	Part Number
R28	Resistor	33K 1/4 W	RC07
R29	"	68K 1/2 W	RC20
R30	"	18K 1/2 W	"
R31	"	1MΩ 1/4 W	RC07
R32	"	18K 1/2 W	RC20
R33	"	1MΩ 1/4 W	RC07
R34	"	18K 1/2 W	RC20
R35	"	1MΩ 1/4 W	RC07
R36	"	18K 1/2 W	RC20
R37	"	1MΩ 1/4 W	RC07
R38		1MΩ 1%	RN65E
R39	"	825K 1%	"
R40	"	1.5K 1/4 W	RC07
R41	"	5MΩ 1%	PME65T9
R42	"	47Ω 1/4 W	RC07
R43	"	49.9K 1%	RN60E
R44			
R45	Potentiometer	100K	79PR
R46	Resistor	5MΩ 1%	PME65T9
R47	"	49.9K 1%	RN60D
R48	"	1.5K 1/4 W	RC07
R49	"	47Ω 1/4 W	"
R50	"	1.10K 1%	RN60D
R51	"	1.10K 1%	"
R52	"	249K 1%	"
R53	"	100Ω 1%	"
R54	"	3.9K 1/4 W	RC07
R55	"	330Ω 1/4 W	"
R56	"	1K 1/4 W	"
R57	"	1K 1/4 W	"
R58	"	1K 1/4 W	"
R59	"	1K 1/4 W	"
R60	"	1K 1/4 W	"
R61	"	2.2 - 2.7K 1/4 W (selected)	"
R62	"	1K 1/4 W (selected)	"

Reference		Description	Part Number
R63	Resistor	1.10K 1% (selected)	RN60D
R64	"	1.00K 1% (selected)	RN60E
R65	"	15K 1%	"
R66	"	15K 1%	"
R67	"	7.5K 1%	RN60D
R68	Potentiometer	200Ω	41
R69	Resistor	49.9K 1%	RN60E
R70	"	4.99K 1%	"
R71	"	4.99K 1%	"
R72	Potentiometer	200Ω	41
R73	Resistor	49.9K 1%	RN60E
R74	"	1.0K 1% (selected)	"
R75	"	22K 1/4 W	RC07
R76	"	300K 1/4 W (selected)	"
R77	"	1K 1/4 W	"
R78	"	4.7K 1/4 W	"
R79	"	270Ω 1/4 W	"
R80	"	4.7K 1/4 W	"
R81	"	10K 1/4 W	"
R82	"	56K 1/4 W	"
R83	"	100K 1/4 W	"
R84	"	10K 1/4 W	"
R85	"	56K 1/4 W	"
R86	"	100K 1/4 W	"
R87	"	10K 1/4 W	"
R88	"	56K 1/4 W	"
R89	"	100K 1/4 W	"
R90	"	10K 1/4 W	"
R91	"	56K 1/4 W	"
R92	"	100K 1/4 W	"
R93	"	1K 1/4 W	"
R94	"	4.7K 1/4 W	"
R95	"	4.7K 1/4 W	"
R96	"	33K 1/4 W	"

Reference	Description		Part Number
C1	Capacitor, 4 µF 250V Elect.	C-D	BR4-250
C2	" 250 µF 25V Elect.	Sprague	TVA-1208
C3	" 50 µF 25V Elect.	Amp.	C426AR-F50
C4			
C5	" 250 µF 25V Elect.	Sprague	TVA-1208
C6			
C7	" 1600 µF 10V Elect.	Amp.	C437AR-D1600
C8	" 330 pF 1 kV Disc	Centr.	DD331
C9			
C10			
C11	" 2000 pF 1 kV Disc	Centr.	DD202
C12	" 1000 pF Mica	Elm.	DM20-102J
C13	" 5000 pF 50V Disc	Centr.	CK502
C14	" 200 pF 1 kV Disc	Centr.	DD201
C15	" 1000 pF Mica	Elm.	DM20-102J
C16	" 1 µF 50 V Mylar	Sprague	431P1059R5
C17	" 22 pF 1 kV Disc	Centr.	DD220
C18	" 1000 pF 1 kV Disc	Centr.	DD103
C19	" 1000 pF 1 kV Disc	Centr.	DD103
C20	" .025 µF 50V Disc	Centr.	CK253
C21	" 0.68 µF 35V Tant.	Sprague	196D684X0035DB
C22	" 0.68 µF 35V Tant.	Sprague	196D684X0035DB
C23	" 3.3 pF 1 kV Disc	Centr.	DD3R3
C24	" 470 pF 1 kV Disc	Centr.	DD471
C25	" 330 pF 1 kV Disc	Centr.	DD331
C26	" .01 µF 100V Mylar	Elm.	1DP-1-103
C27	" 1000 pF 1 kV Disc	Centr.	DD102
C28	" 5000 pF 50V Disc	Centr.	CK502
C29	" 15 pF 1 kV Disc	Centr.	DD150
C30	" 1 µF 35V Tant.	Sprague	196D105X0035DB

Reference	Description		Part Number
A1	Amplifier, Integrated Operational	801A	Analog Devices
1C1	Decade Counter	SN7490N	T.I.
1C2	" "	"	"
1C3	" "	"	"
1C4	" "	"	"
1C5	Latch, Integrated Quad	N7475B	Signetics
1C6	" " "	"	"
1C7	" " "	"	"
1C8	" " "	"	"
1C9	Decoder, BCD to DEC	N7441B	"
1C10	" "	"	"
1C11	" "	"	"
1C12	" "	"	"
1C13	Latch, Integrated Quad	N7475B	"
1C14	Dual Amplifier	MC1437L	Motorola
1C15	2-input Quad Gate	MC846P	"
1C16	" "	"	"
1C17	3-input Gate	MC862P	"
1C18	2-input Quad Gate	MC846P	"
1C19	Hex Inverter	MC836P	"
1C20	J-K Flip-flop	MC845P	"
1C21	Operational Amplifier	U6E7741393	Fairchild
CR1	Diode, Silicon	1N4004	
CR2	" "	1N4001	
CR3	" "	"	
CR4	" "	"	
CR5	" "	"	
CR6	Rectifier, Bridge	MDA920-A1	Motorola
CR7	" "	"	"
CR8	" "	"	"
CR9	" "	"	"
CR10	Diode, Zener, 5.1V 5%	.4M5.1AZ	Motorola

Reference	Description		Part Number	
CR11	Diode, Silicon	1N457	Motorola	
CR12	" "	"	"	
CR13	" "	"	"	
CR14	" "	"	"	
CR15	Diode, Zener	1N829		
CR16	Diode, Silicon	1N914		
CR17	" "	"		
Q1	Transistor, Silicon NPN	2N2219	Motorola	
Q2	" " "	MPS-2924	"	
Q3	" " PNP	2N4037	RCA	
Q4	" Darlington	D28C1	GE	
Q5	" Silicon PNP	2N4126	Motorola	
Q6	" " NPN	MPS-2924	"	
Q7	" " "	2N3877A	GE	
Q8	" " "	"	"	
Q9	" " "	"	"	
Q10	" " "	MPS-2924	Motorola	
Q11	" " "	TRS-2504	Industro	
Q12	" " "	"	"	
Q13	Transistor, Field Effect	2N4093		
Q14				
Q15	" "	2N5457	Motorola	
Q16	" "	2N4093		
Q17	" "	"		
Q18	" Silicon NPN	MPS-2924	Motorola	
Q19	Transistor, Unijunction	2N4870	"	
Q20	" Silicon, NPN	MPS-2924	"	
Q21	" " PNP	2N4126	"	
Q22	" " "	"	"	
Q23	" " "	"	"	
Q24	" " "	"	"	
Q25	" " NPN	MPS-2924	"	

TABLE OF REPLACEABLE PARTS
C/L REFERENCE UNIT 71E

Reference		Description	Mfr.	Part Number
R101	Resistor	47 KΩ 5% 1/2W	AB-EB	301127
R102	"	169 Ω 1% 1/4W	Corning NA60D	315068
R104	"	1.65KΩ 1% 1/4W	"	315092
R105				
R106	"	16.9KΩ 1% 1/4W	"	315117
R111	"	604Ω 1% 1/4W	"	315082
R113	"	60.4Ω 1% 1/4W	"	315058
R115	"	10Ω 1% 1/4W	"	315039
R116	"	13Ω 1% 1/4W	"	315042
R117	"	220KΩ 5% 1/2W	AB-EB	301143
R119	"	4.7KΩ 5% 1/2W	"	301103
R201	"	1KΩ 5% 1/2W	AB-EB	301187
R202	"	510KΩ 5% 1/2W	"	301152
R203	"	820Ω 5% 1/2W	"	301085
R204	"	13Ω 1% 1/4W	Corning NA60D	315042
R205	"	330KΩ 5% 1/2W	AB-EB	301147
R206	"	470Ω 5% 1/2W	AB-EB	301079
R207	"	12KΩ 5% 1/2W	"	301113
		13KΩ 5% 1/2W	"	301114
		15KΩ 5% 1/2W	"	301115
		18KΩ 5% 1/2W	"	301117
		20KΩ 5% 1/2W	"	301118
		22KΩ 5% 1/2W	"	301119
		24KΩ 5% 1/2W	"	301120
		27KΩ 5% 1/2W	"	301121
		30KΩ 5% 1/2W	"	301122
		33KΩ 5% 1/2W	"	301123
		36KΩ 5% 1/2W	"	301124

Reference		Description	Mfr.	Part Number
R207	Resistor	39KΩ 5% 1/2W	AB-EB	301125
	"	43KΩ 5% 1/2W	"	301126
	"	47KΩ 5% 1/2W	"	301127

NOTE: R207 is selected by the calibration department.

R208	Resistor	1.21KΩ 1% 1/4W	Corning NA60D	315089
R209	"	1KΩ 5% 1/2W	AB-EB	301087
R210	"	510KΩ 5% 1/2W	"	301152
R211	"	820Ω 5% 1/2W	"	301085
R212	"	330KΩ 5% 1/2W	"	301147
R213	"	470Ω 5% 1/2W	"	301079
R214	"	1KΩ 5% 1/2W	"	301087
R215	"	510KΩ 5% 1/2W	"	301152
R216	"	150Ω 1% 1/4W	Corning NA60D	315067
R217	"	390Ω 5% 1/2W	AB-EB	301077
R218	"	33KΩ 5% 1/2W	"	301123
R219	"	46.4Ω 1% 1/2W	IRC DC6	306079
R220	"	470Ω 5% 1/2W	AB-EB	301079
R301	"	2KΩ 5% 1/2W	AB-EB	301094
R302	"	470Ω 5% 1/2W	"	301079
R303	"	6.8KΩ 5% 1/2W	Corning C-5	315012
R304	Potentiometer	1KΩ ±10%	AB JA2N200P102UE	311111
R305	Resistor	6.8KΩ 5% 1/2W	Corning C-5	315012
R306	"	243Ω 1% 1/4W	Corning NA60D	315072
R307	"	"	"	"
R401	Resistor	68KΩ 5% 1/2W	AB-EB	301131
R402	"	180KΩ 5% 1/2W	"	301141
R403	"	110Ω 5% 1/2W	"	301064
R404	"	470Ω 5% 1/2W	"	301079
R405	"	33KΩ 5% 1W	AB-GB	302137

Reference		Description	Mfr.	Part Number
R406	Resistor	33KΩ 5% 1W	AB- GB	302137
R407	Potentiometer	10KΩ ±5% Lin. ±0.25%	Bourns 3509S-18-RC 10 Turns	311260
R408	Resistor	43KΩ 5% 1/2W	Corning C-5	315005
R409	"	160KΩ 5% 1/2W	" C-20	315440
R410	"	"	"	315440
R411	"	6.8KΩ 5% 1/2W	Corning C-5	315012
R412				
R413	"	20KΩ 5% 1/2W	AB-EB	301118
R414	"	100Ω 1% 1/2W	T.I. MC60D	326031
R415	Potentiometer	3KΩ 20%	IRC 34-1610-7827	311112
R416	Resistor	20KΩ 5% 1/2W	AB-EB	301118
R417	"	100Ω 1% 1/2W	T.I. MC60D	326031
R418	"	1MΩ 5% 1/2W	AB-EB	301159
R419	"	33KΩ 5% 1/2W	"	301123
R420	"	130KΩ 5% 1/2W	"	301138
R421	"	2.7KΩ 5% 1/2W	"	301097
R422	"	2.[illegible]MΩ 5% 1/2W	"	301167
R423	"	51KΩ 5% 1/2W	"	301128
R424	"	20KΩ 5% 1/2W	"	301118
R425	"	100Ω 1% 1/2W	T.I. MC60D	326031
R426	"	"	"	"
R427	"	20KΩ 5% 1/2W	AB-EB	301118
R428	"	2.2MΩ 5% 1/2W	"	301167
R501	Potentiometer	5KΩ ±20%	CTS 34-5204 Type Q	311101
R502	"	"	"	"
R503	"	"	"	"
R504	"	"	"	"
R505	"	"	"	"
R506	"	"	"	"
R507	Resistor	4.99KΩ 1% 1/4W	Corning NA60D	315103
R508	"	10KΩ 1% 1/2W	Corning NA65D	315411

Reference		Description	Mfr.	Part Number
R601	Resistor	20KΩ 5% 1/2W	AB-EB	301118
R602	Potentiometer	250KΩ 20%	CTS 34-5203B Type Q	311103
R603	Resistor	2.2MΩ 5% 1/2W	AB-EB	301167
R604	"	1MΩ 5% 1/2W	"	301159
R605	"	4KΩ 5% 10W	Ohmite 1707	312119
C101	Capacitor, Fixed	0.068 µF 200F	Sprague 192P22492	234051
C102	" Var.	8.7 pF/Sect.	Johnson 1604305	275138
C103	" Fixed	120 pF 5% 500V	Arco DM-15F-121J	200002
C104	" Var.	50 pF		275139
C105	" "	0.7 - 3 pF	Erie 535-008-4R	279109
C106	" Fixed	0.033 µF 200V	Sprague 192P33392	234045
C107	" Var.	140 pF	Hamm. APC 140	275104
C108	" Fixed	0.02 µF 500V	Erie 841Z5V203P	224118
C109	" "	"	"	"
C110	" "	97 pF		200040
C111	" Var.	0.7 - 3 pF	Erie 535-008-4R	279109
C112	" "	"	"	"
C113	" Fixed	0.01 µF 200V	Sprague 192P10392	234027
C114	" "	0.1 µF 200V	Sprague 192P10492	230116
C115	" "	0.022 µF 200V	Sprague 192P22392	230101
C201	Capacitor, Fixed	0.001 µF 200V 10%	Sprague 192P10292	234039
C202	" "	0.02 µF 500V	Erie 841Z5V20	224118
C203	" "	0.1 µF 25V	Erie 5815-000-1042	224124
C204	" "	0.02 µF 500V 20%	Erie 841Z5V203P	224118
C205	" "	150 pF 500V		200032
C206	" "	0.02 µF 20% 500V		224118
C207	" "	0.01 µF 10% 200V		234027
C208	" "	0.1 µF 25V	Erie 5815-000-1042	224124
C209	" "	0.02 µF 20% 500V	Erie 841Z5V203P	224118
C210	" "	150 pF 5% 500V		200032
C212	" "	0.01 µF 10% 200V		234027

Reference		Description	Mfr.	Part Number
C213	Capacitor, Fixed	560 pF 5% 300V	Arco DM15-561J	200029
C214	" Var.	7 - 45 pF	Erie 503-041-D2PO-24R	275114
C215	" Fixed	0.02 µF 20% 500V	Erie 841Z5V203P	224118
C216	" "	150 pF 5% 500V	Arco DM15-151J	200032
C217	" "	0.02 µF 500V	Erie 841Z5V203P	224118
C218	" "	470 pF 5% 300V	Arco DM15-471J	200028
C301	Capacitor, Fixed	0.02 µF 20% 500V	Erie 841Z5V203P	224118
C302	" "	"	"	"
C303	" "	"	"	"
C304	" "	0.1 µF 10% 200V	Sprague 192P10492	230116
C305	" "	430 pF 1% 500V	Arco DM15-431F	200037
C306	" "	"	"	"
C307	" "	0.022 µF 20% 200V	Sprague 192P22302	230101
C308	" "	"	"	"
C401	Capacitor, Fixed	56 pF 5% 400V	Arco DM15-560J	200030
C402	" "	250 pF 5% 500V	Arco DM15-251J	200036
C403	" "	0.02 µF 20% 500V	Erie 841Z5V203P	224118
C404	" "	0.02 µF 20% 500V	"	"
C405	" "	"	"	"
C406	" "	"	"	"
C407	" "	0.001 µF 500V	Erie 86125V	224114
C408	" "	10 µF 6V	Sprague TE-1087	283130
C409	" "	20 µF 6V	Sprague TE-1090	283153
C410	" "	0.01 µF 10% 200V	Sprague 192P10392	234027
C411	" "	1.0 µF 100V	Sprague TE-1400	283175
C412	" "	25 µF 6V	Sprague TE-1091	283177
C501	" "	0.1 µF 10% 200V	Sprague 192P10492	230116

Reference	Description	Mfr.	Part Number
C601	Capacitor, Fixed 0.01 µF 10% 600V	Sprague 220P 6PS-10	234077
C602	" " "	"	"
C603	" " 50 µF 12V	Sprague TE-1133	283176
C604	" " 20/20 µF 450V	Mallory FP-134	283100
DIODES			
D201	Diode, Silicon	1N251	T.I.	530043
D202	" "	"	"	"
D203	" "	"	"	"
D204	" "	"	"	"
D301	Diode, Silicon	1N914	T.I.	530058
D302	" "	"	"	"
D401	Diode, Silicon	1N251	T.I.	530043
D402	Diode, Zener, 7.5V 5%	1N755A	Motorola	530066
D403	Diode, Silicon	1N251	T.I.	530043
D404	" "	"	"	"
D405	" "	"	"	"
D406	" "	"	"	"
D501	Diode, Silicon	1N2070		530088
D601	Diode, Silicon	1N251	T.I.	530043
FUSES			
F101	Fuse	1/4 Amp 250V	Bussman AGC-1/4	545506
F601	Fuse, Slo-Blo	0.5 Amp 250V (117V Units)	Bussman MDL	545504
		0.25 Amp 250V (230V Units)	"	545511
F602	Fuse, Slo-Blo	0.25Amp 250V (117V Units)	Bussman MDL	545511
		1/8 Amp 250V (230V Units)	"	545516

Reference	Description	Mfr.	Part Number
INDUCTORS			
L101	Coil Unit		400123
L102	" "		400122
L103	Toroid Coil Assembly		071176
L104	Choke, 220µH 5%	Nytronics Wee-220	400118
L105	" "	"	"
L201			
L202	Choke, 1000µH 5%	Nytronics	400095
L203	Coil, 105-200 µH		400117
L204	" "		"
L205	Choke, 220µH 5%	Nytronics	400118
L206	Choke, 47 µH	Miller 9210-60	400076
L207	Choke, 1000µH 5%	Nytronics	400095
L208	Choke, 100 mH 20%	Stanwyck Dink - 100,000	400176
L209	" "	"	"
L210	" "	"	"
L301	Choke, 4.7 mH 5%	Nytronics RFC-L-10000	400102
L501	Choke, 4.7 mH 5%	Essex RFC-14700	400102
L601	Choke, 7 H 50mA dc 550 ohms	Stancor C1707	440001
TRANSFORMERS			
T101	Input Transformer Assembly		071012
T201	Output transformer Assembly		071181

Reference	Description	Mfr.	Part Number
TRANSFORMERS			
T301	Phase Detector Transformer Assembly		071179
T401	Oscillator Transformer Assembly		071008
T601	Power Transformer		446025
VACUUM TUBES			
V201	Tube, 6CB6	RCA	5266CB6
V202	" "	"	"
V203	" "	"	"
V301	Tube, 6CB6	RCA	5266CB6
V401	Tube, 6BE6	RCA	5266BE6
V402	Tube, 12AX7	Telefunken	525001
V601	Tube, 6X4	Envelope size JETEC-5-3	5266X4
CRYSTALS			
Y401	Crystal, 1 MHz Type CR-37/U	J. Knight HC-131V	547015

PARTS LIST
DIGITAL DISPLAY UNIT 94B

Reference		Description	Mfr.	Part Number
R701	Resistor	1MΩ 1%	T.I. MC60D	326700
R702	"	1.3MΩ 5% 1/2W	AB Type EB	301162
R703	"	100K to 100.5K (8)		340911
		or		
		100.5K to 101K (9)		340910
		or		
		99.5K to 100K (10)		340909
		or		
		99K to 99.5K (11)		340908
R704	Potentiometer	1000Ω 20%	CTS 360T-360PC102B	311257
R705	Resistor	10,200 to 10,251 (4)		340907
		or		
		10,251 to 10,302Ω (5)		340906
		or		
		10,149 to 10,200Ω (6)		340905
		or		
		10,098 to 10,149Ω (7)		340904
R706	Potentiometer	100Ω 20%	CTS 360T-360PC101B	311258
R707	Resistor	1100 to 1105.5Ω (0)		340903
		or		
		1105.5 to 1111Ω (1)		340902
		or		
		1094.5 to 1100Ω (2)		340901
		or		
		1089 to 1094.5Ω (3)		340900

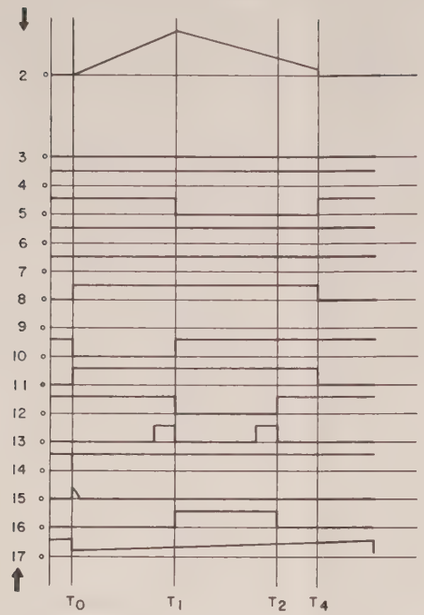
NOTE: Resistors R703, R705 and R707 must be of the same number group in any particular instrument, i.e. 1-5-9 : 0-4-8 : 2-6-10 OR 3-7-11

R708	Resistor	18Ω 5% 1/2W	AB-EB	301045
R709	"	22Ω 5% 1/2W	AB-EB	301047
R710	"	1000Ω 5% 1/2W	"	301087
R711	"	1.2KΩ 5% 1/2W	"	301089
R712	"	10KΩ 5% 1/2W	"	301111

Reference		Description	Mrf.	Part Number
R713	Resistor	10K 5% 1/2W	AB-EB	301111
R714	"	330Ω 5% 1/2W	"	301075
R715	"	100KΩ 5% 1/2W	"	301135
R716	"	6.04K 1%	T.I. MC60D	340333
R717	"	180KΩ 5% 1/2W	AB-EB	301141
R718	Potentiometer	1KΩ ±5% Lin. ±0.25% 10 turn	Bourns 3509S-1-102	311261
R719	Potentiometer	10KΩ ±5% Lin. ±0.25% 10 turn	Bourns 3509S-1-103	311260
R720	Potentiometer	100KΩ -5% Lin. -0.25% 10 turn	Bourns 3509S-1-104	311259
R721	Resistor	100Ω 5% 1/2W	AB-EB	301063
R722	"	1KΩ 5% 1/2W	"	301087
C701	Capacitor	10μF 250V	Sprague TVA 1504	283210
C702	"	10pF 500V 5%	Arco DM-10C-100J	200022
C703	"	10μF 250V	Sprague TVA 1504	283210
C704	"	240 pF 500V 5%	Arco DM15-241J	200506
C705	"	10 μF 250V	Sprague TVA 1504	283210
C706	"	0.1 μF 25V	Erie 5815-000-104Z	224124
C708	"	1000 μF 50V	Sprague TVL 1338	283201
C707	"	200 μF 250V	Sprague TVL 1547	283209
C709	"	0.1 μF 200V 10%	Sprague 192P10492	230116
CR701	Diode, Silicon	1N2070		530088
CR702	" "	"		"
CR703	" "	"		"
CR704	" "	"		"
CR705	" "	"		"
CR706	" "	"		"
CR707	" "	"		"
CR708	" "	"		"

Reference			Description	Mfr.	Part Number
CR709	Diode,	Silicon	1N2070		530088
CR710	"	"	"		"
CR711	"	"			"
CR712	"	"	"		"
CR713	"	"	"		"
Q701	Transistor, NPN Silicon			Motorola MJE340	528040

Test Points on Schematic Diagram 8304548

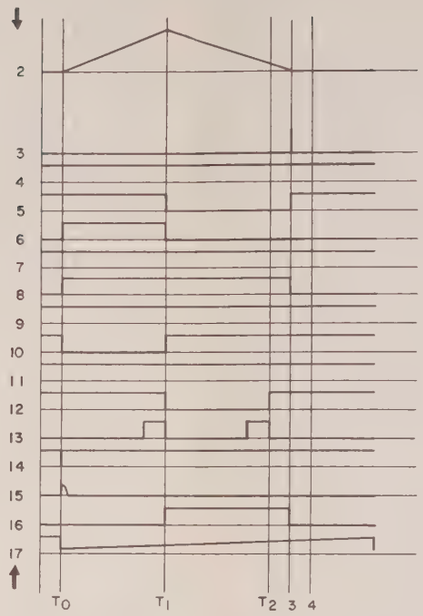


TIMING DIAGRAM 1

+1.5 VOLT INPUT - LOGIC TESTING
TO = RESET
T1 = 10,000 COUNTS
T2 = SECOND 10,000 COUNTS
T4 = SHUTDOWN AT 24,000 TOTAL COUNTS

NIXIES SHOULD NOT BE LIT, O/R LAMP SHOULD BE ON.

Test Points on Schematic Diagram 8304548

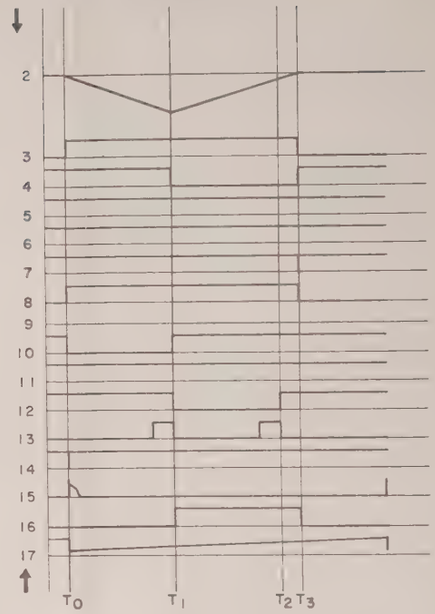


TIMING DIAGRAM 2

+1.2 VOLT INPUT
TO = RESET
T1 = 10,000 COUNT REFERENCE
T2 = SECOND 10,000 COUNTS
T3 = SHUTDOWN AT 22,000 TOTAL COUNTS

NIXIES SHOULD REMAIN LIT.

Test Points on Schematic Diagram 8304548



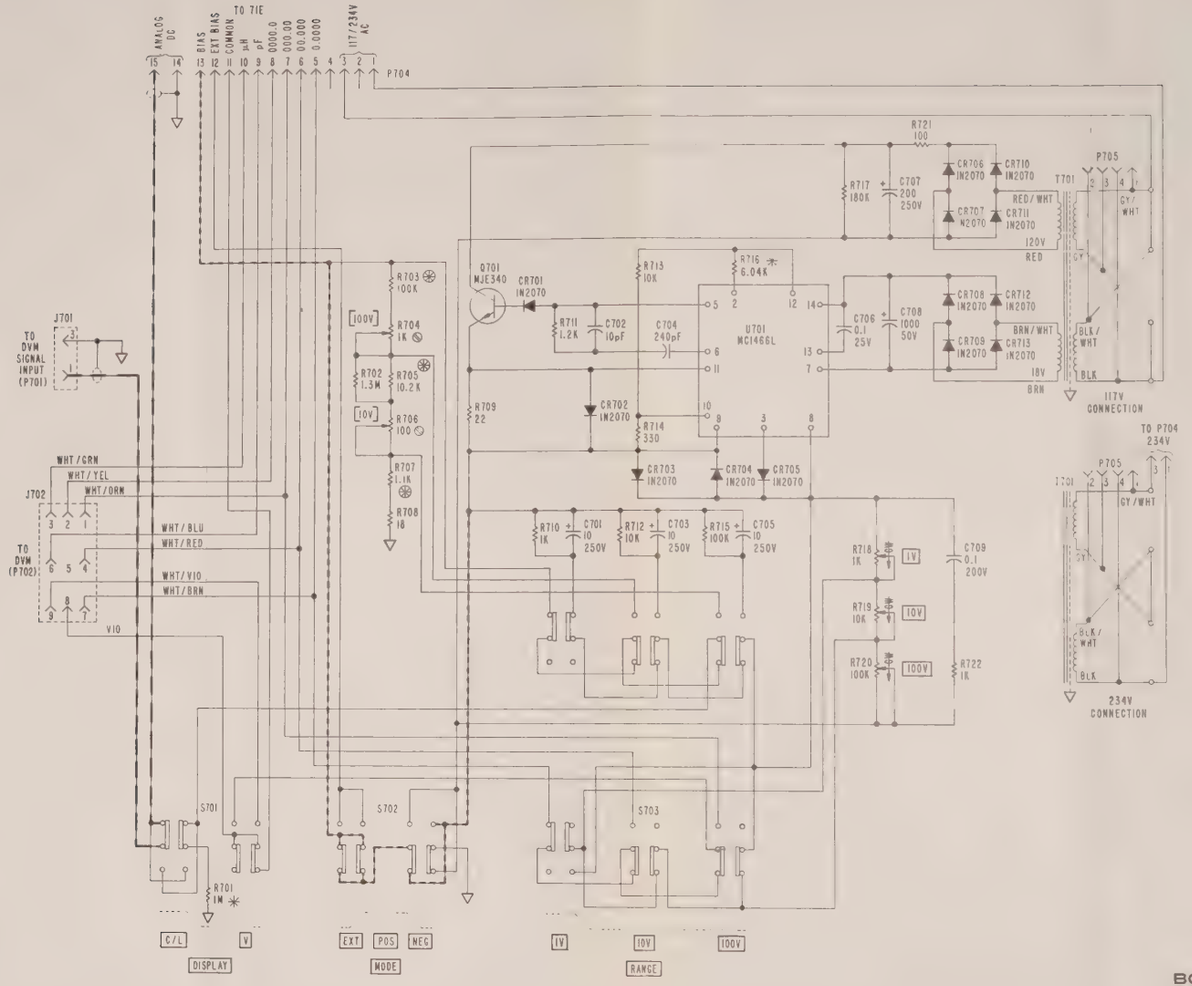
TIMING DIAGRAM 3

-1.2 VOLT INPUT

SIMILAR TO +1.2V INPUT, BUT - SIGN SHOULD LIGHT.

TEST POINT ONE, OUTPUT OF A1, SHOULD ALWAYS BE AT $-5E_{IN}$, FOR ALL E_{IN} BELOW 2 VOLTS.

THE PEAK VALUE OF THE RAMP AT T.P.2 SHOULD BE APPROXIMATELY $7E_{IN}$ BELOW 1.5 VOLTS.

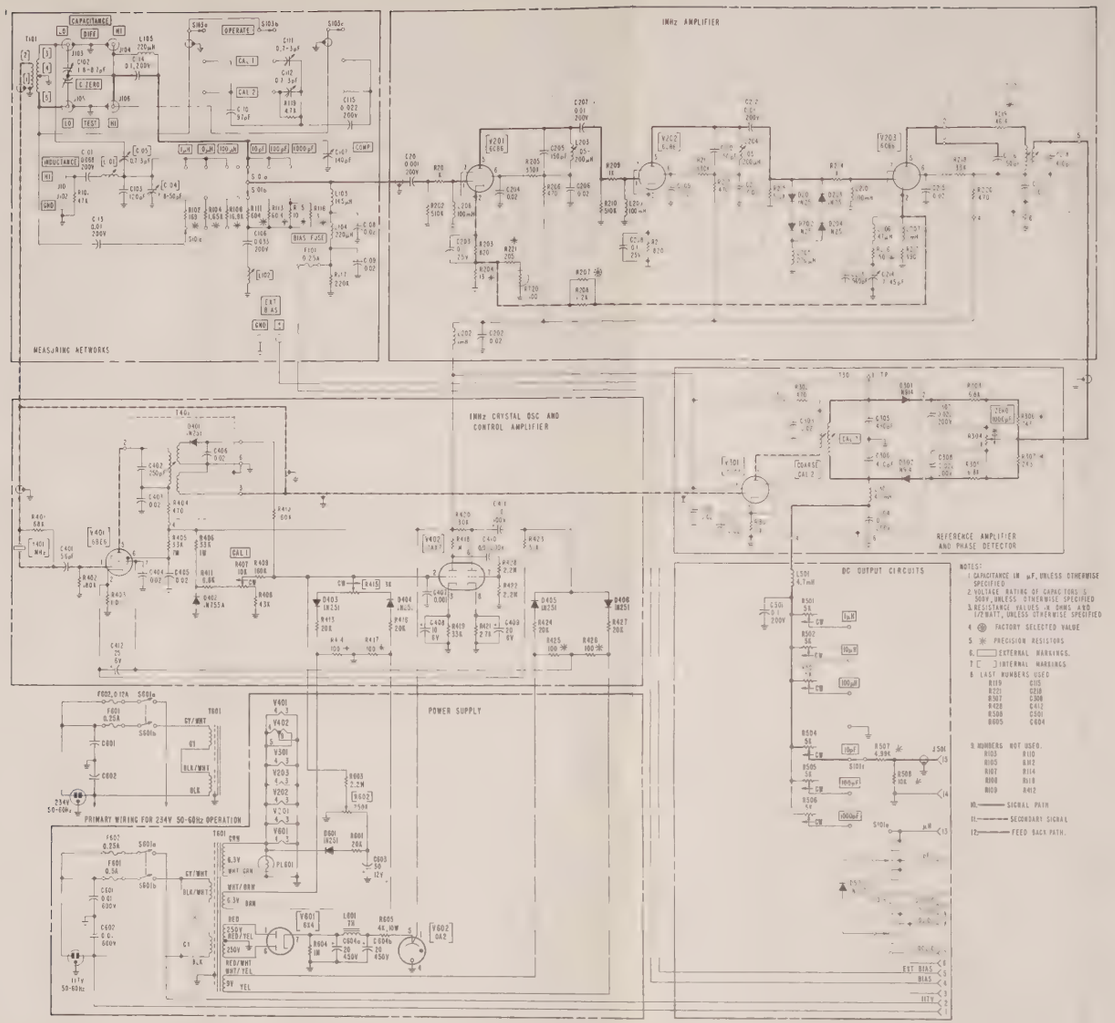


NOTES:

1. CAPACITANCE VALUES IN μF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS AND 1/2 WATTS, UNLESS OTHERWISE SPECIFIED.
3. SWITCHES SHOWN IN C/L POSITION AND 1 VOLT POSITIVE INTERNAL BIAS.
4. ✳ PRECISION RESISTOR.
5. ⊛ FACTORY SELECTED PRECISION RESISTOR.
6. ——— ANALOG DC SIGNAL
7. - - - - - DC BIAS
8. ▭ EXTERNAL MARKINGS
9. [ ] INTERNAL MARKINGS
10. ⊘ INTERNAL CONTROL
11. ▽ COMMON
12. LAST NUMBERS USED: R722, C709

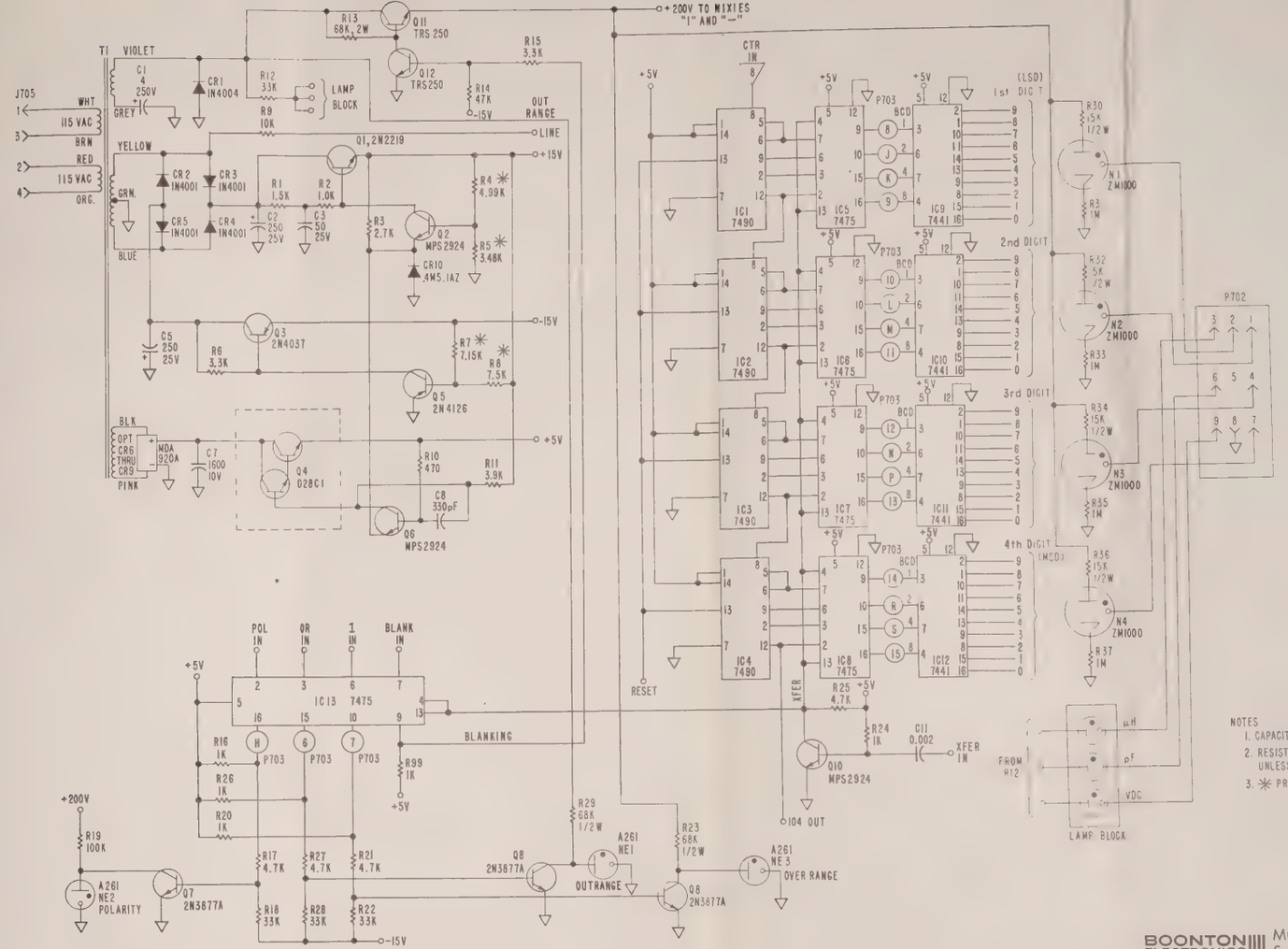
BOONTON ELECTRONICS CORPORATION

MODEL 700C
Schematic, Bias Supply
830453B



BOONTON ELECTRONICS CORPORATION

MODEL 700C
Schematic, C/L Ref. Unit
830452D

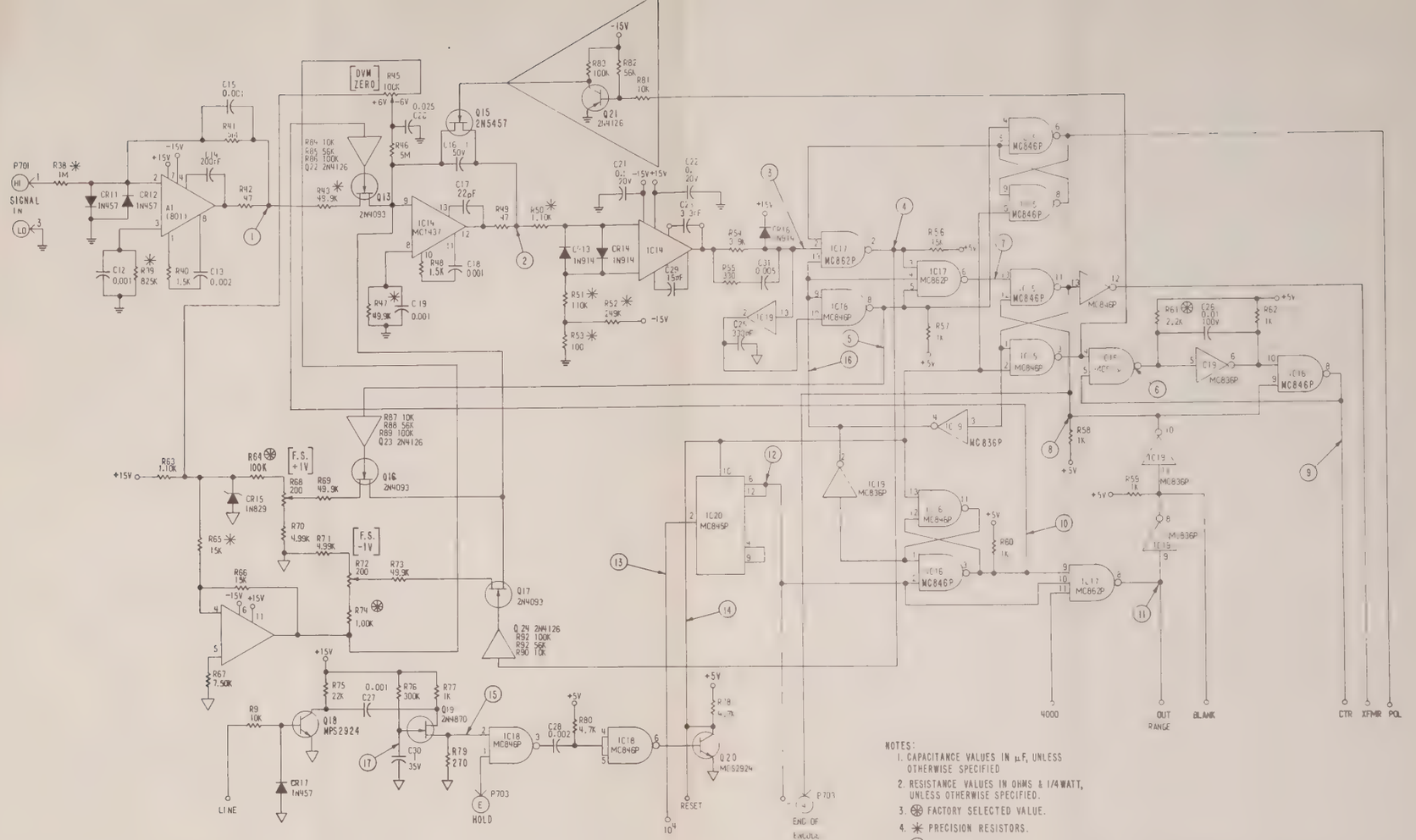


NOTES

1. CAPACITANCE IN μF, UNLESS OTHERWISE SPECIFIED.
2. RESISTANCE VALUES IN OHMS & 1/4 WATT, UNLESS OTHERWISE SPECIFIED.
3. ✳ PRECISION RESISTORS.

BOONTON ELECTRONICS

MODEL 700C
Schematic, Digital Display Unit
830454C Sh. 1 of 2



NOTES:

1. CAPACITANCE VALUES IN μF, UNLESS OTHERWISE SPECIFIED
2. RESISTANCE VALUES IN OHMS & 1/4 WATT, UNLESS OTHERWISE SPECIFIED.
3. ⊛ FACTORY SELECTED VALUE.
4. ✳ PRECISION RESISTORS.
5. ○→ TEST POINTS

BOONTON ELECTRONICS

MODEL 700C
Schematic, Digital Display Unit
830454B Sh. 2 of 2

Warranty

Boonton Electronics Corporation warrants its products to the original Purchaser to be free from defects in material and workmanship and to operate within applicable specifications for a period of one year from date of shipment, provided they are used under normal operating conditions. This warranty does not apply to vacuum tubes that have given normal service, to sealed assemblies which have been opened, or to any item which has been repaired or altered without our authorization.

We will repair or, at our option, replace at no charge any of our products which are found to be defective under the terms of this warranty. Except for such repair or replacement, we will not be liable for any incidental damages or for any consequential damages, as those terms are defined in Section 2-715 of the Uniform Commercial Code, in connection with products covered by this warranty.

BOONTON ELECTRONICS CORPORATION

Telephone: 201-887-5110
TWX: 710-986-8241

Route 287, Parsippany, N. J. – 07054

MP MASTER
MA24784